General starting situation:
Busy traffic tunnels with passenger and goods transport

Active and passive fire protection – which way should we go?
This question given with the title concerns technical, operational, and commercial matters as well!
Basic reflection
Using effective measures against fire is not at all a new idea!
Since many decades it is systematically followed in the field of:
- Industrial plants
- Storage facilities
- Warehouse departments
- Public assembly places
with combustible masses more or less lying steadily in the same place

Basic reflection
In contrast the combustible masses in traffic tunnels are moving which makes it more difficult to handle a starting fire.

Basic reflection
Designing any industrial or commercial facility raises immediately the question:
What is the best?
An active or a passive fire protection or a combination of both?
In industrial or commercial facilities usually active fire protection measures are supplemented by passive ones.

Active Fire Protection
Fixed Fire Fighting Systems as:
- Low or high pressure water mist
- Sprinklers
- Deluge systems

Advantages:
- Avoidance of fire spreading
- Improved accessibility of the fire place
- Better protection of infrastructure

Disadvantages:
- Destratification of smoke layer
- More complex equipment
- Reduction of visibility

Fixed Fire Fighting Systems
- do not extinguish large fires
- are often overestimated with regard to their capability

BUT
- slow down the fire development
- reduce or avoid fire jump from car to car
- improve by that conditions for escape
- better protection of infrastructure
Fixed Fire Fighting Systems

Require:
• precise and early detection
• efficient localisation of fire
• activation at right time

Fire Detection
To trace vehicle fire
• fastly
• reliably

Aiming at immediate
• information of tunnel users
• modification of tunnel operation

Basic Requirements to Fixed Fire Fighting Systems
• at any time functionable
• reliable even under the rough conditions of tunnel atmosphere (moist and salty air, dust, soot)
• acceptable investment costs
• low maintenance costs
• Easy to install and to use

Automatic Fire Suppression
Advantages of water based systems:
• Fire and smoke restricted to shorter tunnel section
• Cut down of fire jump from one car to another
• Cooling effect
Problems of water based systems:
- immediately reduced visibility
- destratification of smoke
- no or low efficiency for fires inside vehicles
- in special cases dangerous chemical reactions

Automatic Fire Suppression

Australian experience:
- in urban road tunnels with
  - manned control center or
  - video/automatic incident detection facilitating precise event location
- to minimize fire growth
- to reduce probability of flashover

Automatic Fire Suppression

Dutch experience:
- no extinction of fire inside vehicle
- immediate reduction of visibility
- large amount of steam if fire > 15 MW
- reduced risk of fire propagation
Japanese experience:
- no fire extinction at all
- cut down of fire jump from one car to another
- cooling effect for tunnel structure
- no immediate activation to keep better escape conditions
- no promotion of sprinklers in tunnels intended

Questions left with Fixed Fire Fighting Systems
- Is there any economic compensation given with the investment for a FFFS – e.g. savings for ventilation?
- What is the mutual impact of various components of safety systems?

Fixed fire suppression systems
- world wide so far not often installed
- intensive global discussion regarding:
  - optimal time of activation
  - cost benefit effects

L-surF Project

Design Study for a Large Scale Underground Research Facility on Safety and Security
2005 – 2008
VSH (CH) + 5 partners
- feasibility study to establish a pan-European test facility
- scientific and technological research
- business plan for test programme
www.l-surf.org

Recent German research project

Safety of Life in Tunnels
Passive Fire Protection

Structural components of a tunnel as:
• mineral boards or plasters
• fire resistant concrete tunnel lining
• enlarged concrete cover and additional reinforcement layer
• special perforated steel sheet

Advantages:
• no operational maintenance
• no failings

Fire protection of tunnel lining

• mineral cladding / mineral plaster
• large covering and additional reinforcement
• perforated steel plates with foaming coating
• fire resistant concrete

Heating up of bars < 300 ° C
Minimization of spalling

Mineral Boards and Plaster (1)

Advantages:
• installation in already existing tunnels
• mostly no maintenance
• no risk of failing in case of fire

Mineral Boards and Plaster (2)

Disadvantages:
• larger excavation cross section
• longer construction time
• risk for absorption of seapage water causing loss of thermal insulation capacity
• risk of local falling down due to increase of dead weight
Mineral Boards and Plaster (3)

Disadvantages:
- risk for corrosion of board fasteners
- no visual access of lining for inspection
- renewal after 25 to 30 years: 3 to 4 times during life cycle of a tunnel
- risk of partial falling down due to sucking and pressure load of fast trucks

Fire resistant Concrete

Special mix required:
- maximum core group of aggregates consisting of basaltic gravel
- quartzite, no chalky aggregates
- addition of 3 kg/m³ Polypropylene fibres
- quality class ≥ C 25/30

Fire resistant Concrete

- several years research work by:
  - Hochtief AG (contractor)
  - TU Braunschweig, Germany
  - STUVA, Cologne, Germany
- fire test 1200 C° over 90 minutes
- no severe spalling, locally restricted only
- spalling depth less than 10 mm
Fire resistant Concrete:
advantages during construction
• omission of fire proof cladding
• smaller excavated cross section
• shorter construction time
• sufficient fire protection already during construction
• simpler assembling of tunnel installations

BUT
• not applicable in existing tunnels

Fire resistant Concrete:
advantages during operation
• free access for tunnel inspection
• life cycle like for the tunnel
• no problems caused by sucking and pressure loads of fast trucks
• problem-free tunnel cleaning
• no problems with water seepage
• low damage in case of vehicle collision
• nearly no spalling in case of fire

Enlarged concrete cover for structural reinforcement
Requires additional layer of steel mat set up towards the fire affected side of the lining to reduce spalling

Disadvantages:
• increase of costs
• thicker lining
• additional working step

Perforated steel sheet with foaming coating
Passive Fire Protection

• avoids structural disintegration
• reduces spalling

BUT
• does not prevent fire spreading
• does not cause any cooling effect
• gives no protection for persons and vehicles

Passive Fire Protection

meets only some of the important objectives

BUT
we need a holistic fire safety concept with:
• best chances for a successful escape
• optimum safety for tunnel users
• use of all available technical options

Conclusion

Active and passive fire protection – which way should we go?

We need an efficient and balanced combination of both!

Active fire protection measures can only be complimentary to passive ones as useful component in a holistic fire safety concept!

This has proven to be very effective, useful, and pragmatic in the field of industrial and commercial facilities.

Many thanks for your attention!